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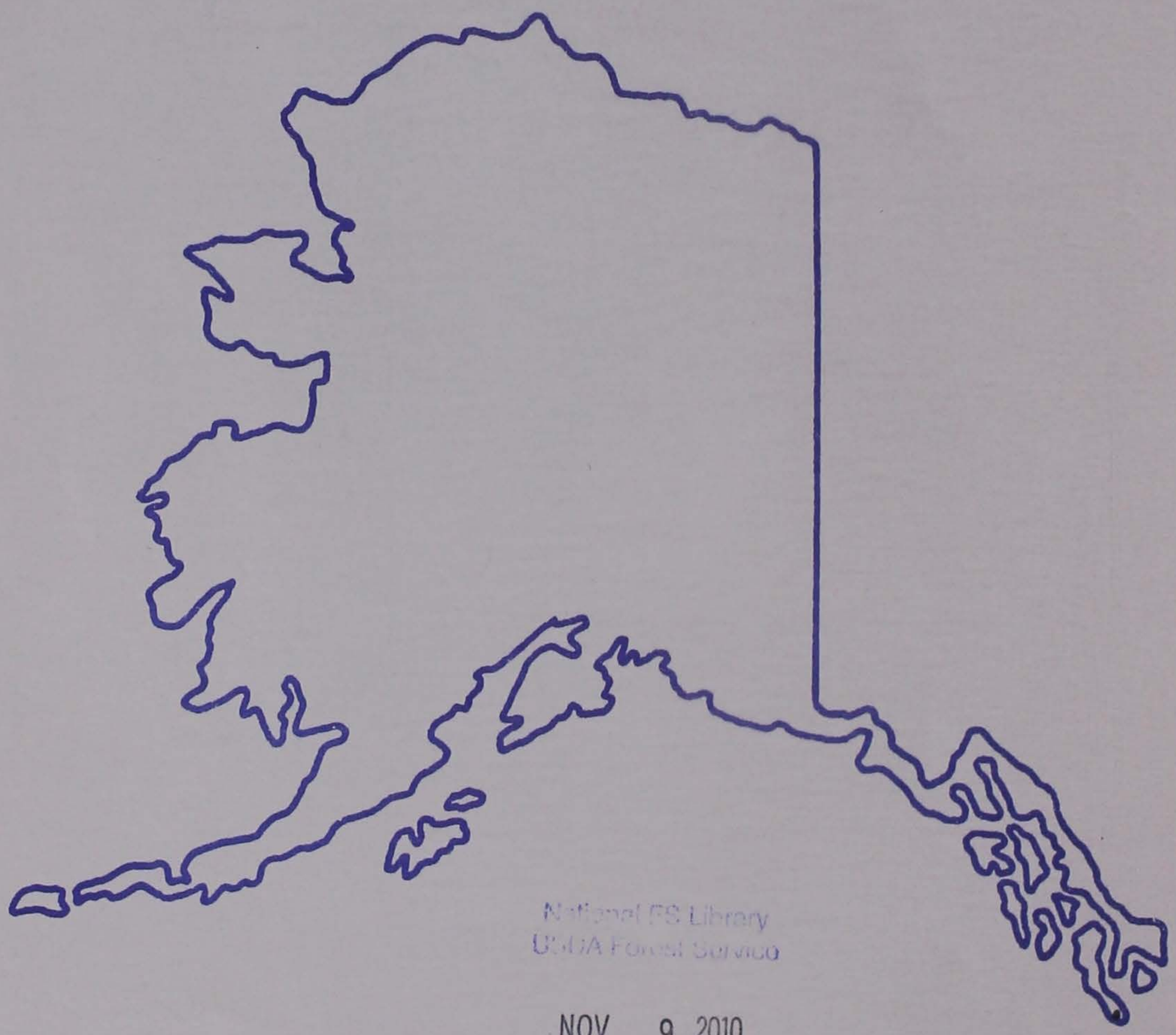
Forest Pest Management Report

FPM General Technical Report R10-TP-20

Survival, growth, grazing, and shoot blight of planted Alaska yellow-cedar seedlings in southeast Alaska

May 1991



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Survival, growth, grazing, and shoot blight of planted Alaska yellow-cedar seedlings in southeast Alaska

✓ DIB 9-5-97

May 1991

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Survival, growth, grazing, and shoot blight of planted Alaska yellow-cedar seedlings in southeast Alaska

Abstract. Seedlings of Alaska yellow-cedar (*Chamaecyparis nootkatensis* (D. Don.) Spach) were planted on Etolin Island in southeast Alaska and measured annually for four years to evaluate survival and growth performance on different types of sites and microsites. Seedling survival and growth were best on sites with adequate light exposure and soil moisture drainage, but were poor on sites with heavy shade or with impeded drainage. Burned clearcut sites supported the best survival, height growth, and diameter growth among site types. Shoot blight, caused by the fungus *Apostrasseria* sp., was common on sites where natural vegetative reproduction of Alaska yellow-cedar was present nearby. Grazing by deer was common on some site types, but deer only consumed new growth and few seedlings were killed. On productive sites, grazed seedlings maintain rapid diameter growth and appeared capable of rapid height growth unless they are grazed in successive years. Grazing reduces seedlings' ability to compete with adjacent vegetation. This study demonstrates that planted Alaska yellow-cedar on productive sites have good survival and growth. Recommendations include planting soon after harvesting to reduce competition from brush and hemlock, avoidance of poorly drained sites or microsites, burning as site-preparation, and the use of protection from deer grazing.

INTRODUCTION

Alaska yellow-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) has outstanding wood characteristics and is consistently the most valuable wood grown in Alaska. A large scale forest decline has caused concentrated mortality on at least 400,000 acres in southeast Alaska since about 1880 (4). This mortality has occurred on sites with poor or moderately poor drainage (3). The primary cause of decline is not known, but all recent research indicates that decline is not caused by any contagious biological agent (2,5). In fact, decline has apparently not spread to any new sites since its onset more than 100 years ago (3). Thus, the mortality factor, even though still unknown, does not threaten plantations of this valuable species on sites where decline does not now occur.

Despite the great value of Alaska yellow-cedar, little is known about its regeneration requirements in Alaska. The species is known to regenerate naturally on wet sites by vegetative layering (6), but generally does not reproduce well by seed. Unfortunately, sites with a large cedar component that are clear-cut harvested in southeast Alaska regenerate naturally to western hemlock and Sitka spruce. Regeneration by Alaska yellow-cedar on these sites is either absent or extremely limited.

Thus, forest decline and timber harvesting are diminishing the populations of cedar in southeast Alaska and these losses are not offset by natural regeneration. Clearly, the planting of cedar or some silvicultural method for attaining natural regeneration will be needed to replace these losses. The objective of this study is to perform a preliminary evaluation of general planting requirements for planted seedlings of Alaska yellow-cedar and to determine biotic factors that may limit their survival and growth in southeast Alaska.

METHODS AND MATERIALS

Seedlings. All Alaska yellow-cedar seedlings used in this study were grown at the USDA Forest Service nursery in Petersburg, Alaska. Seeds for the seedlings were collected on Mitkof and adjacent islands, all within about 50 miles of the eventual planting location. Seedlings were grown in styrofoam cell container in the greenhouse for two years before planting. All seedlings were measured before planting; heights were 42.2 $\pm$ 0.19 cm and diameter was 4.0 $\pm$ 0.03 mm (means $\pm$ standard errors).

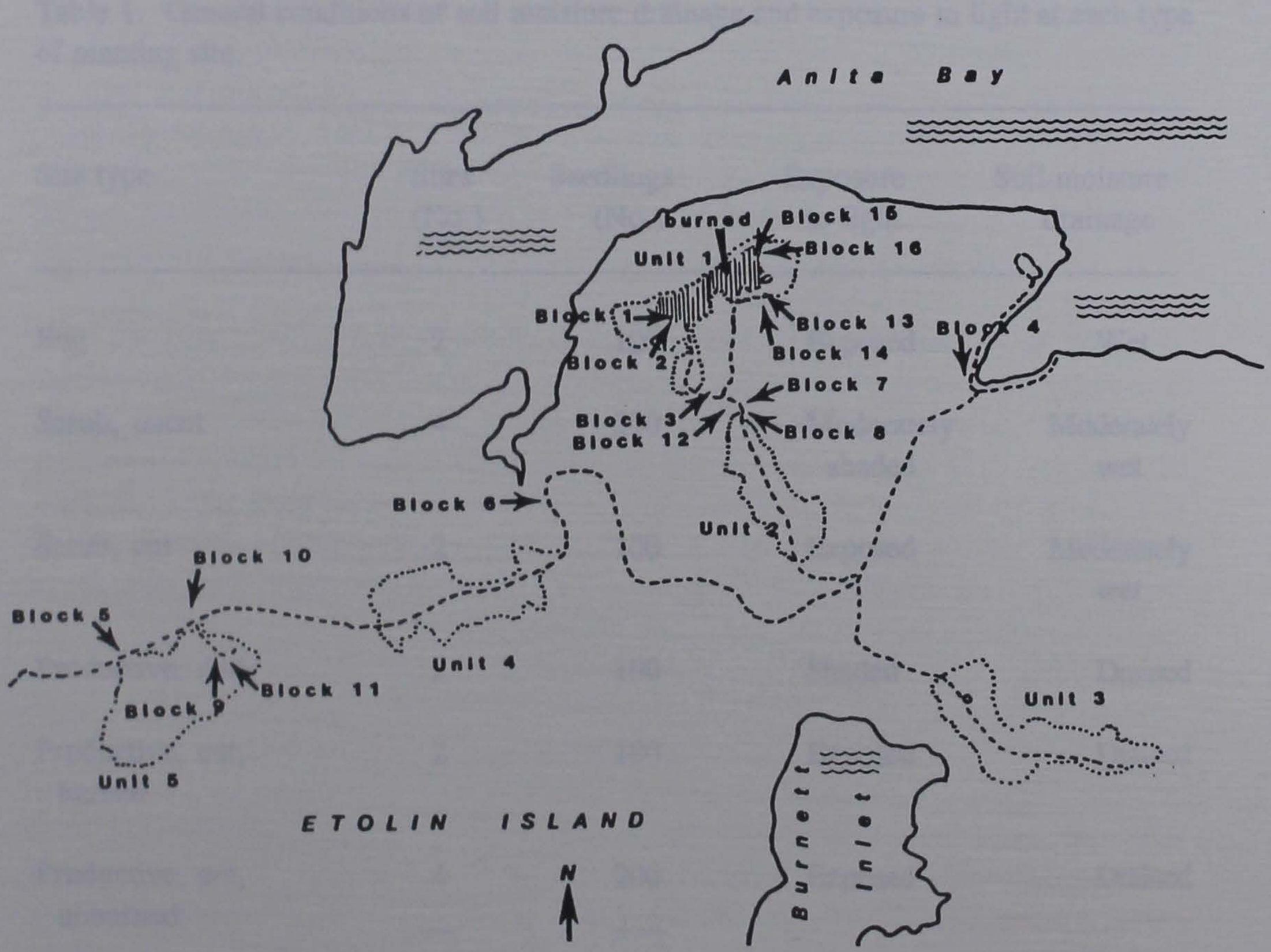

Figure 1. Location of 16 planting blocks on Etolin Island, Alaska

Study location. Seedlings were planted at 16 locations (Fig. 1) near Anita Bay on Etolin Island. Seedlings were planted using hoedad tools during several days of warm, dry weather during June 1986. A small numbered aluminum tag was attached to each seedling and a stake flag was placed in the ground so that seedlings could be relocated.

Study design. A total of 800 seedlings of Alaska yellow-cedar were planted, 50 seedlings at each of 16 sites. At each site, seedlings were planted in five rows of ten seedlings. Adjacent seedlings and rows were 12 feet apart. Seedlings were not fertilized or protected from deer. Each planting site represented one of the following: open bog, low volume (scrub) stand of Alaska yellow-cedar or a similar stand that had recently been clearcut, high volume stand that was uncut, high volume stand that had been clearcut and was unburned or subsequently burned (Table 1). These sites represented some combination of poor, moderate, or good soil moisture drainage and poor, moderate, or good exposure to light. For example, bogs generally had poor drainage and good light exposure.

Table 1. General conditions of soil moisture drainage and exposure to light at each type of planting site.

Site type	Sites (No.)	Seedlings (No.)	Exposure to light	Soil moisture drainage
Bog	2	100	Exposed	Wet
Scrub, uncut	4	200	Moderately shaded	Moderately wet
Scrub, cut	2	100	Exposed	Moderately wet
Productive, dark	2	100	Shaded	Drained
Productive, cut, burned	2	100	Exposed	Drained
Productive, cut, unburned	4	200	Exposed	Drained
Totals	16	800		

Light exposure and soil drainage were noted for the specific planting location as each seedling was planted. Exposure to light varied for seedlings planted in the uncut scrub type where the canopy was open and the density of brush was variable, but was more uniform at all other site types. Excessively wet soils were noted when free water was observed during planting. Bog vegetation or skunk cabbage were typical of these wet microsites. Soil moisture drainage was relatively consistent at a few sites (e.g., poor drainage for all seedlings planted in bogs), but was variable at most other sites. Even the three productive sites (uncut, cut and burned, cut and unburned) had numerous poorly drained microsites.

The physical appearance of the planting substrate was also recorded. The planting site for each seedling was classified as: abundant rotten wood, disturbed soil (mineral soil exposed), adjacent to a stump, or undisturbed duff. A similar classification was used previously by Sidle and Shaw (7) in describing planting microsites of clearcut areas in southeast Alaska.

Measurements. The height and basal diameter were measured for each seedling in 1986 before planting, and then were measured before the initiation of shoot growth each spring through 1990. Seedling height was measured to the nearest centimeter and basal diameter was measured to the nearest millimeter. Browsing by animals and shoot blight, caused by the fungus *Apostrasseria* sp., were also noted annually for each seedling. The color of each seedling was classified each year as: green (91+% green), green-brown (51 to 90% green), brown-green (1 to 50% green), or brown (0% green). Seedlings were judged to be surviving in 1990 if they were green or green-brown.

Data analysis. Differences in the incidence of shoot blight and grazing on seedlings among the site types were tested by chi-square. Differences in average height and diameter of seedlings in 1990 by site type were tested by analysis of variance. Differences between the height and diameter of grazed and ungrazed seedlings from the same site types were tested by student's t. All tests were at the $p \leq 0.05$ level. The frequency of surviving seedlings was charted for each year by site type. Likewise, average seedling height and diameter of live seedlings were charted each year by site type.

RESULTS

Survival. Seedling survival was significantly affected by site type. One year after planting, seedling survival in all site types approached 100%, except for the 81% survival in bogs (Fig. 2). Seedlings in bogs continued to die the second and third year, leaving only 30% of the seedlings alive in 1990. Most of these surviving seedlings in bogs occurred on slightly raised areas (hummocks), but even these seedlings were off-color. Regardless of their site type, brown seedlings consistently had dead cambia.

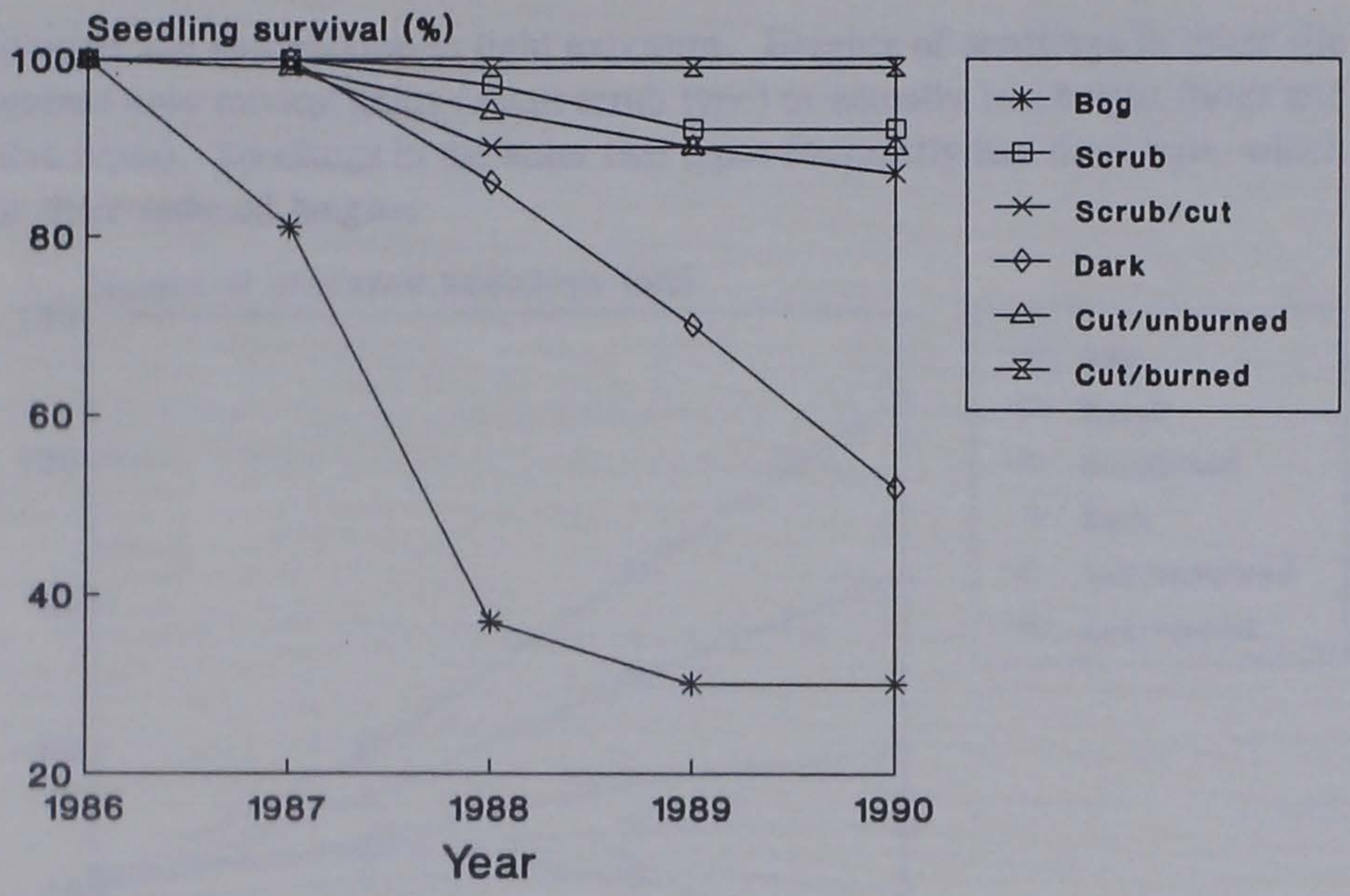

Figure 2. Survival of Alaska yellow-cedar seedlings in six site types from the time of planting in 1986 to 1990.

Seedlings in the dark high volume type appeared healthy one year after planting (98% were green). Within two years, however, many seedlings appeared brown and began to die. Only 53% were alive in 1990 and many of these had dead shoots and dead leaders.

Survival was greater than 85% in all other site types. Nearly all seedlings that died on these sites were planted in wet, poorly drained microsites. These wet microsites occurred in all site types, including those with generally good drainage. Exposure to light did not affect seedling survival on these sites. The productive, burned site type had the best rate of survival (98%).

Growth. Both height and diameter growth of seedlings were significantly affected by site type (Figs. 3,4). Height and diameter results presented here include only those seedlings that were alive and not grazed by deer. Heights of seedlings one year after planting (in 1987) were similar among different site types and were actually several centimeters less than heights measured before planting in 1986 (Fig 3). Presumably, this apparent reduction in height was the result of planting seedlings somewhat deeper than they were planted in the nursery. By the second year (1988), however, seedlings in the burned and unburned productive clearcut sites began rapid growth. This trend continued through 1990 with annual height growth and final heights in 1990 being greatest in burned clearcut sites, followed by seedlings in unburned clearcut sites, and then seedlings in scrub cut sites. Thus, seedling height growth was greatest in the three site types that

had been harvested and had maximum light exposure. Heights of seedlings in other site types had acquired only modest gains (uncut scrub type) or actually lost height (bogs and dark productive types). Seedlings in the latter two types frequently had dead tops, which accounted for their reduced heights.

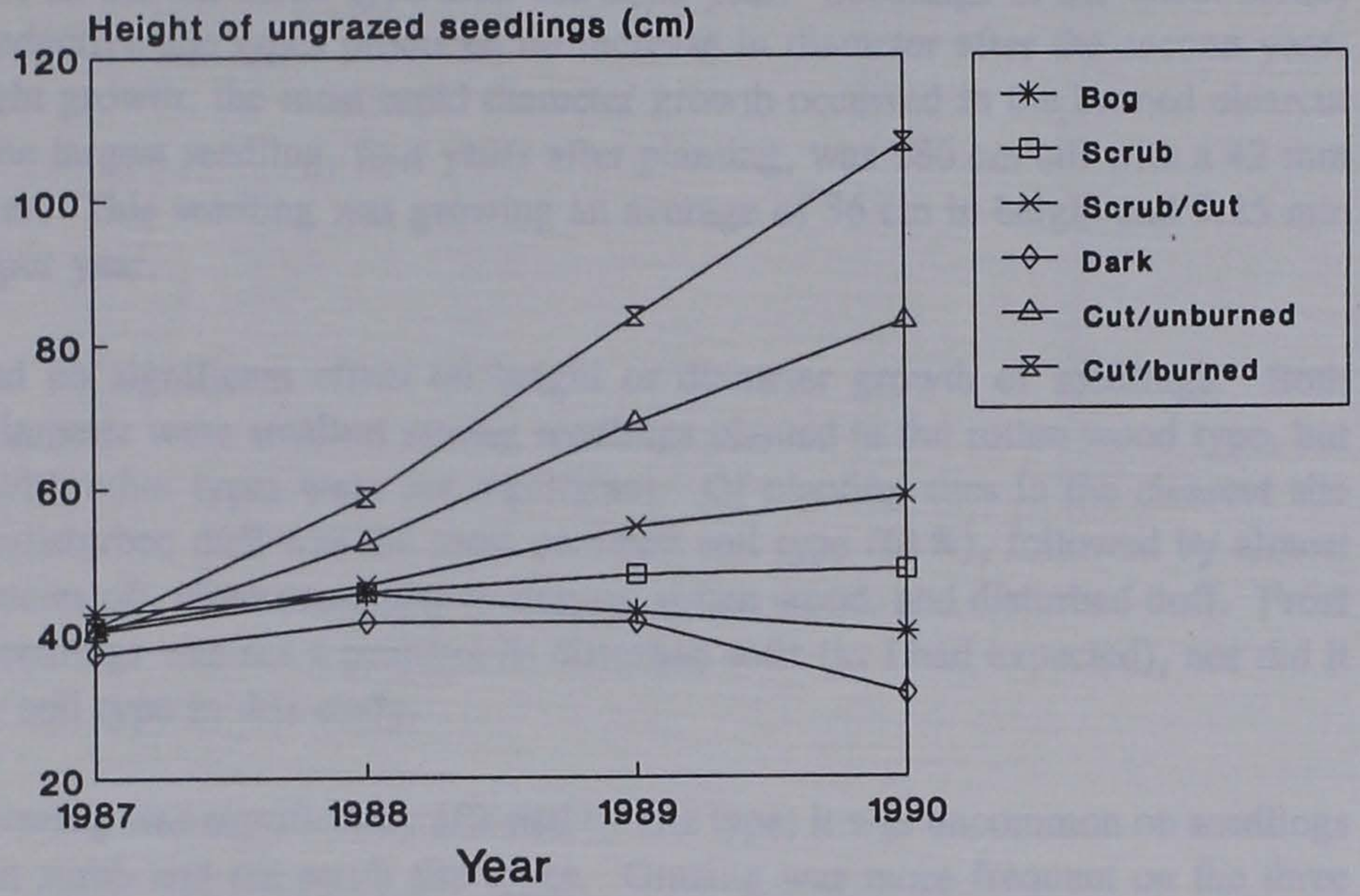

Figure 3. Height growth of ungrazed seedlings of Alaska yellow-cedar planted in six different site types. Some seedlings had reduced height over time because their terminal leaders died.

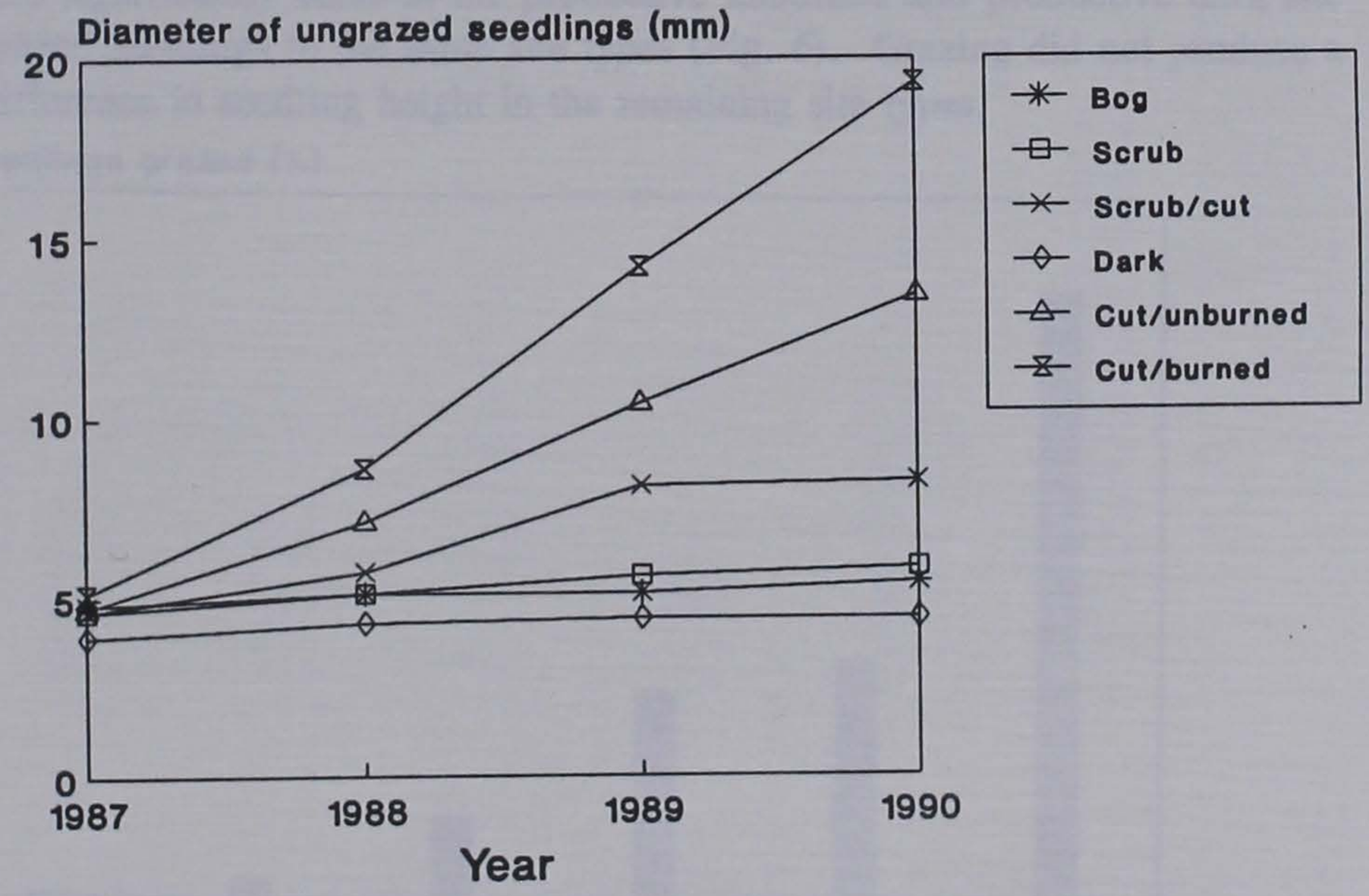

Figure 4. Basal diameter growth of ungrazed seedlings of Alaska yellow-cedar planted in six different site types.

Diameter growth of live seedlings followed the same trend as seedling height growth (Fig. 4). Seedling diameters increased slightly in all site types the first year. From the second year (1988) through the fourth year (1990), seedling diameter increased rapidly in the three clearcut site types (burned, unburned, and cut scrub). Diameter growth began to slow in the cut scrub type after the third year. Seedlings in the uncut scrub, and dark productive site types produced no increase in diameter after the second year. As with height growth, the most rapid diameter growth occurred in the burned clearcut site type. The largest seedling, four years after planting, was 186 cm tall with a 42 mm basal diameter. This seedling was growing an average of 36 cm in height and 9.25 mm in diameter per year.

Soil type had no significant effect on height or diameter growth of seedlings. Both height and diameter were smallest among seedlings planted in the rotten wood type, but differences with other types were not significant. Of planting sites in the clearcut site types, the undisturbed duff was the most common soil type (61%), followed by almost equal frequencies of: close proximity to stumps, rotten wood, and disturbed duff. Frost heaving of seedlings was not a problem in disturbed soils (as I had expected), nor did it occur in any soil type in this study.

Grazing. Grazing was significantly affected by site type; it was uncommon on seedlings in bog, uncut scrub and cut scrub site types. Grazing was more frequent on the three productive site types and reached almost 90% on burned sites (Fig. 5).

Grazed seedlings frequently had bushy crowns and noticeably large diameters. Ungrazed seedlings were significantly taller in the productive unburned and productive dark site types than grazed seedlings in the same site types (Fig. 6). Grazing did not produce a significant difference in seedling height in the remaining site types.

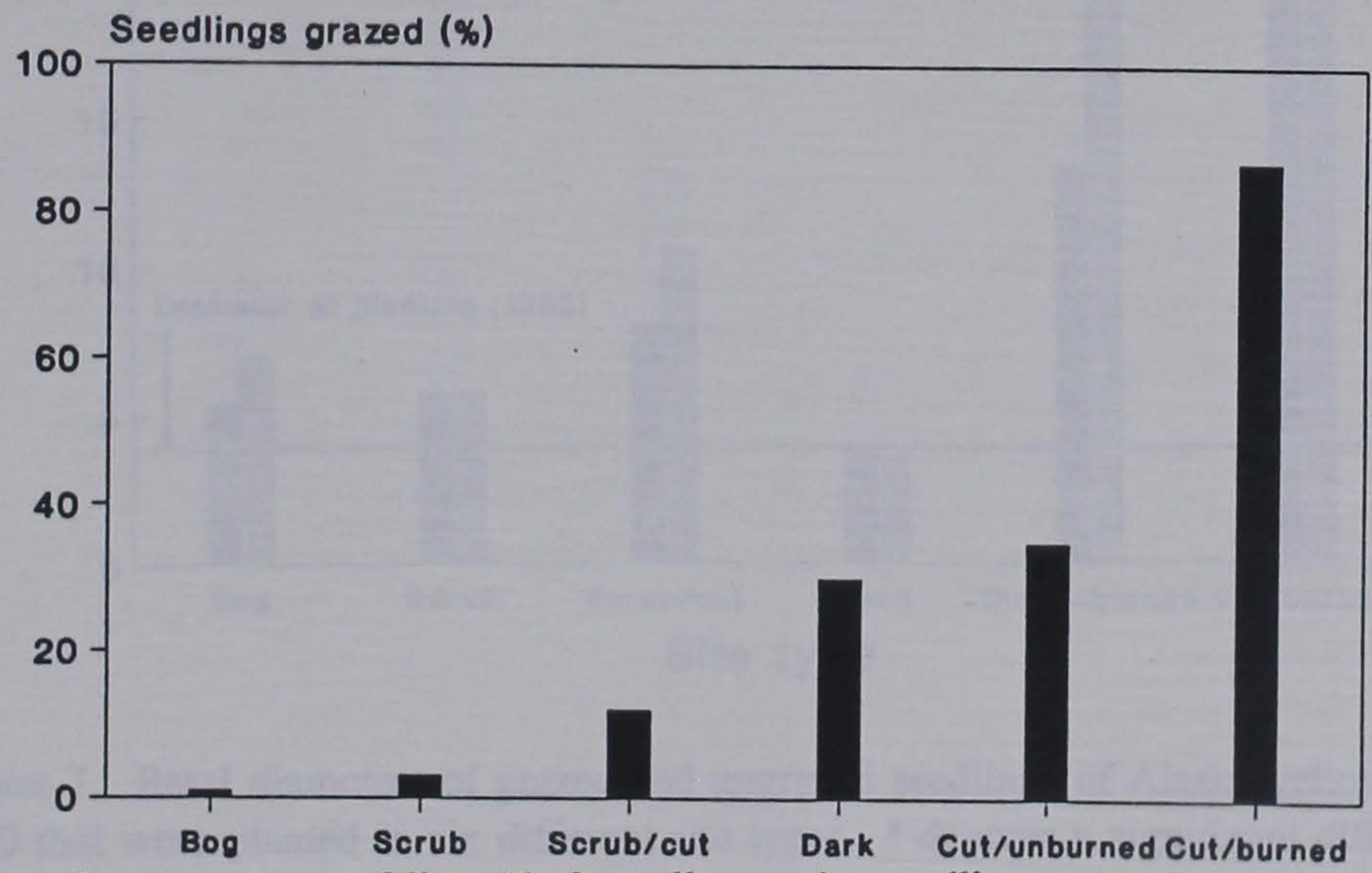

Figure 5. Percentage of live Alaska yellow-cedar seedlings grazed on six site types

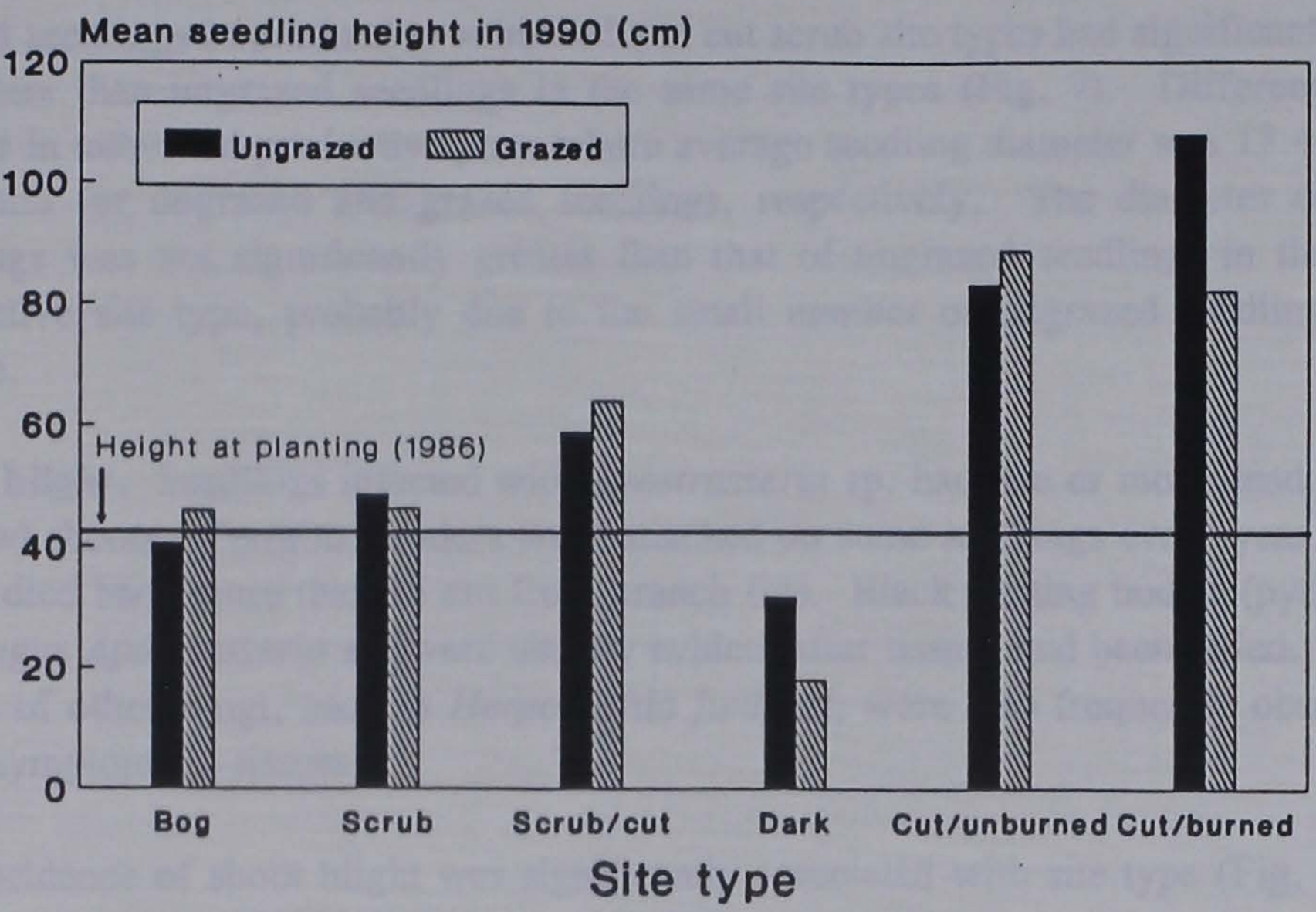

Figure 6. Heights of grazed and ungrazed seedlings of Alaska yellow-cedar in 1990 that were planted in six different site types. Some seedlings were shorter in 1990 than when they were planted because of dead terminal leaders. * denotes a significant difference in heights of grazed and ungrazed seedlings growing in the same site type.

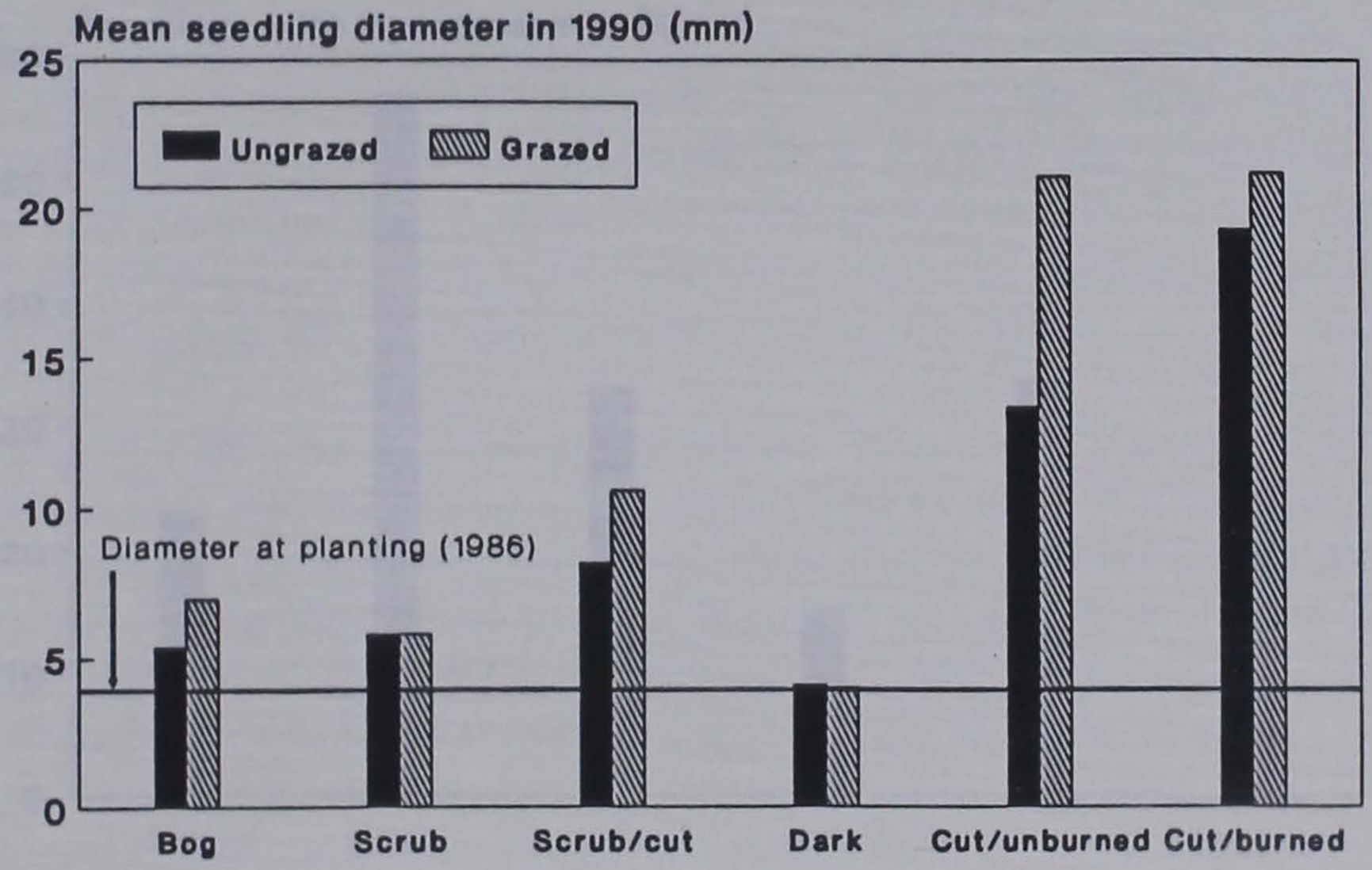

Figure 7. Basal diameters of grazed and ungrazed seedlings of Alaska yellow-cedar in 1990 that were planted in six different site types. * denotes a significant difference in diameters of grazed and ungrazed seedlings growing in the same site type.

Grazed seedlings in productive unburned and cut scrub site types had significantly larger diameters than ungrazed seedlings in the same site types (Fig. 7). Differences were notable in unburned productive plots where average seedling diameter was 13.4 mm and 21.1 mm for ungrazed and grazed seedlings, respectively. The diameter of grazed seedlings was not significantly greater than that of ungrazed seedlings in the burned productive site type, probably due to the small number of ungrazed seedlings in the sample.

Shoot blight. Seedlings infected with *Apostrasseria* sp. had one or more dead or dying (yellow) shoots. Terminal leaders were attacked on some seedlings every year. Shoots rarely died back more than 15 cm from branch tips. Black fruiting bodies (pycnidia) of the fungus *Apostrasseria* sp. were usually evident after tissues had been killed. Fruiting bodies of other fungi, such as *Herpotrichia juniperi*, were also frequently observed on these symptomatic tissues.

The incidence of shoot blight was significantly associated with site type (Fig. 8). The greatest incidence (56% of seedlings by 1990) was on the uncut scrub site type. The productive, dark type had the lowest incidence of shoot blight (15% of seedlings). Microsite features, such as drainage and light exposure, had no apparent effect on the incidence of shoot blight.

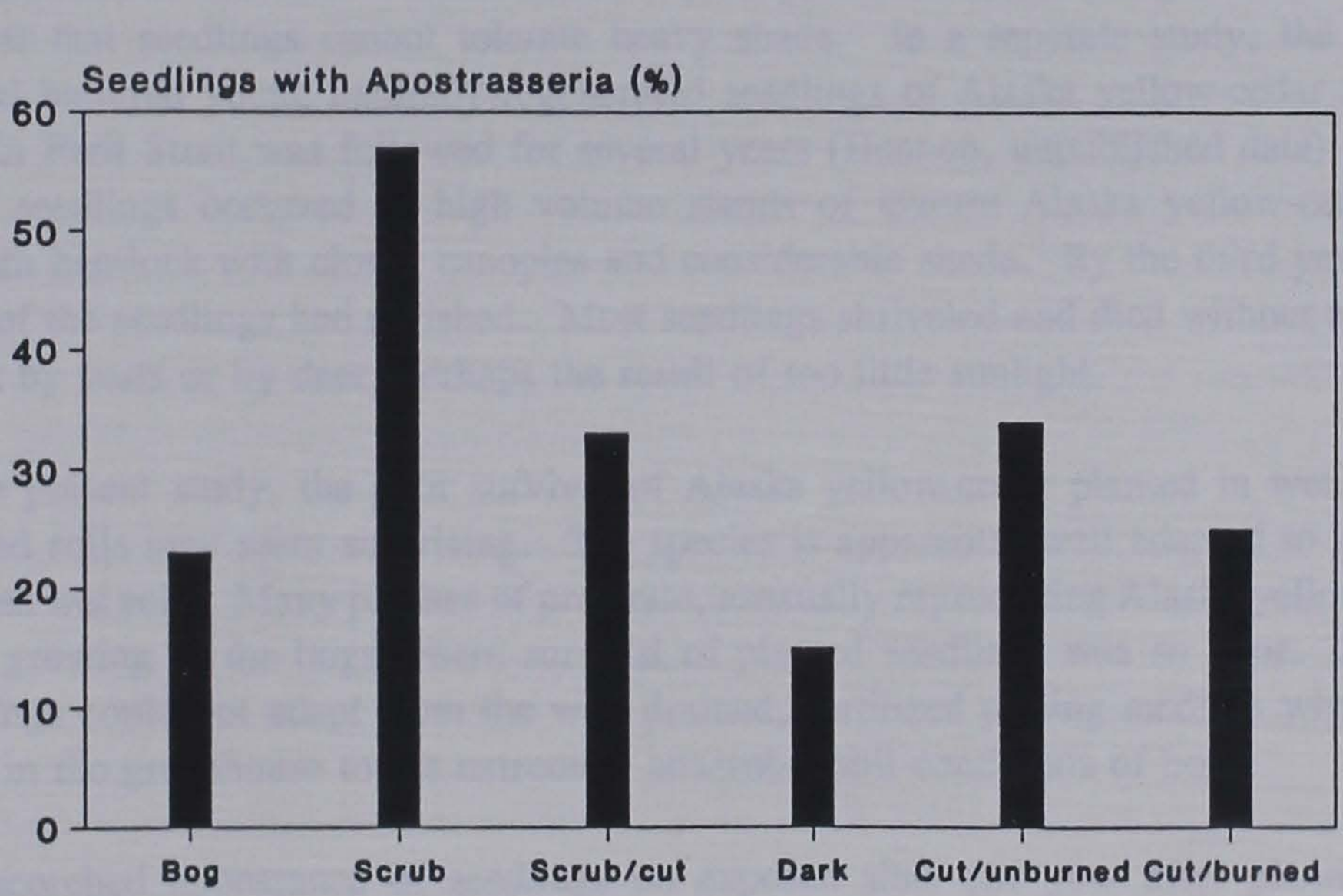

Figure 8. Percentage of live seedlings of Alaska yellow-cedar that were infected with the shoot blight fungus, *Apostrasseria* sp., in six different site types.

One year after planting, numerous seedlings in exposed locations had noticeable symptoms somewhat similar to those caused by *Apostrasseria*. These seedlings lacked the fruiting bodies of the fungus *Apostrasseria*, however. Some 23% of seedlings had a scorched appearance with scattered brownish scales and dead shoot tips. Ninety-eight percent of these seedlings occurred in exposed locations. Most scorched seedlings, particularly those on good sites and microsites, appeared green after another year.

DISCUSSION

This study demonstrates that planted seedlings of Alaska yellow-cedar can successfully establish in southeast Alaska. It also illustrates the overwhelming effect that site factors have on survival and growth of seedlings. On sites with good light exposure and soil moisture drainage, planted seedlings of Alaska yellow-cedar are capable of excellent survival and growth. Survival and growth are particularly good on burned clearcut sites. The fast rate of growth of planted seedlings on burned sites may result from higher concentrations of nutrients or reduced competition by vegetation, or both.

Seedling survival was diminished by heavy shade and poor soil drainage. Although Alaska yellow-cedar has sometimes been considered to be shade tolerant, this feature of its reproduction has never been studied adequately. Results from this preliminary study suggest that seedlings cannot tolerate heavy shade. In a separate study, the fate of several hundred young naturally-regenerated seedlings of Alaska yellow-cedar at three sites in Peril Strait was followed for several years (Hennon, unpublished data). These small seedlings occurred in high volume stands of mature Alaska yellow-cedar and western hemlock with closed canopies and considerable shade. By the third year, over 99% of the seedlings had perished. Most seedlings shriveled and died without apparent attack by pests or by deer, perhaps the result of too little sunlight.

In the present study, the poor survival of Alaska yellow-cedar planted in wet, poorly drained soils may seem surprising. The species is apparently well adapted to growing in these wet soils. Many patches of prostrate, asexually reproducing Alaska yellow-cedar were growing in the bogs where survival of planted seedlings was so poor. Perhaps seedlings could not adapt from the well drained, fertilized potting medium where they grew in the greenhouse to the extremely anaerobic soil conditions of bogs.

The scorched appearance of seedlings on exposed sites one year after planting was probably the result of warm dry weather that occurred during and several days after planting. These seedlings apparently experienced a form of transplant shock due to desiccation. Their good recovery indicates their responsiveness to adverse conditions when planted on good sites.

Biotic factors, such as grazing by deer and infection by *Apostrasseria* sp., only cause mortality in very young seedlings or if older seedlings are repeatedly attacked. At its current level, shoot blight is not causing serious damage even in site types where it is common. The incidence of the disease appears to be intensifying at all sites in the study and this trend may continue for several more years. *Apostrasseria* sp. only causes disease on young trees, however, and stands of Alaska yellow-cedar will eventually outgrow susceptibility. In a survey of pathogenic fungi on mature Alaska yellow-cedars, the fungus was not detected (2,5). Thus, the fungus may cause more damage over the short term and then diminish.

It is conceivable that fungi other than *Apostrasseria* sp. are also causing some of the shoot blight in these young cedars. More study is needed on fungi that kill shoots of Alaska yellow-cedar, including inoculation trials to determine the pathogenicity of *Apostrasseria* sp. on cedar. Also, taxonomic study is needed to describe this new fungal species.

Seedlings of Alaska yellow-cedar are more seriously damaged by deer than by shoot blight. Because only recently-grown tissues of seedlings are grazed by deer, most grazing does not result in direct mortality. Terminal and lateral shoots near the tops of seedlings are most frequently grazed, resulting in some grazed seedlings that are short and bushy.

The time of year that grazing occurs is unknown, but it is possible that deer are feeding on whatever parts of seedlings emerge from snow during winter when other food is unavailable. Or, deer may be selecting newly produced foliage, regardless of snow or time of year. The high incidence of grazing in productive clearcuts and productive dark sites may indicate that these are areas of important deer habitat. Planted seedlings in burned units appear conspicuous in winter because of the sparsity of other vegetation. This may lead to a greater rate of grazing on these site types compared with other sites. Also, seedlings growing on burned units may be more nutritious to deer.

Grazing of seedlings on productive sites has the effect of delaying height growth. Diameter growth is actually enhanced in grazed seedlings (presumably so is root growth) and seedlings may attempt to resume their shoot/root balance by accelerating height growth in ensuing years. One or two years after grazing, one lateral shoot usually becomes dominant. If seedlings go ungrazed for a year or two, they should attain heights on productive sites that will not allow deer to feed upon their terminal leaders. Seedlings grazed in the past have an appearance that suggests that if seedlings can go ungrazed for a year or two, tree form will not be affected.

On the other hand, seedlings planted in areas of dense deer populations may experience grazing every year. By their reduced height, grazed seedlings will be at a disadvantage with competing vegetation. Such seedlings will probably not survive competition for

light and nutrients with species of brush (e.g., *Vaccinium* spp., *Menziesia ferruginosa*, etc.) and western hemlock. Some planted cedar seedlings in unburned clearcuts were grazed in consecutive years and were becoming overtopped by hemlock and brush in 1990. The combination of deer grazing and competing vegetation may be the greatest threat to survival of Alaska yellow-cedar seedlings on well drained microsites.

Silviculturists on the Tongass National Forest suggest that natural regeneration cannot be relied upon to provide adequate recruitment of Alaska yellow-cedar under current clear-cut harvesting practices. Delayed germination of seeds may be partially responsible for poor establishment by natural regeneration. Seeds often lie dormant on the ground for more than a year after release from cones, allowing the competitive advantage to other vegetation that responds more quickly to disturbance. When cedar germlings finally emerge, they may be engulfed by surrounding vegetation. Evidence from the current study suggests that Alaska yellow-cedar may be relatively shade intolerant; thus, seedlings may perish under a canopy of brush and hemlock. Seedling growth was poor on one well-drained unburned site where planting was conducted several years after clearcutting. On this site, hemlock, *Vaccinium*, and other species had overgrown many of the planted seedlings.

Fire may offer an alternative to planting. The excellent survival and growth of seedlings on burned sites in this study demonstrate some advantages to burning. The reduction of competing vegetation, including advanced regeneration of western hemlock, is an important factor in survival of Alaska yellow-cedar seedlings. Burning may encourage natural regeneration of Alaska yellow-cedar, as well. A maturing 90-year mixed stand of Alaska yellow-cedar and western hemlock apparently regenerated naturally following a fire on Cannery Point in Tenakee Inlet on Chichagof Island. It is not clear if fire, a reduction in the deer population, or some other factors were responsible for the establishment of two 100+ year-old even-aged stands of Alaska yellow-cedar in Sitka (Jon Martin, personal communication).

Some combination of burning and artificial dispersal of seed or burning and seed tree management might successfully regenerate Alaska yellow-cedar. Burning a site that contains seed trees would almost certainly kill Alaska yellow-cedar seed trees because of their thin bark. But if the timing of burning could be conducted in the summer during a year of heavy seed release in fall, then this technique could prove useful. Thus, instead of clearcut harvesting a stand with Alaska yellow-cedar on a productive site, scattered cedars with good form and bearing cones could be marked and would remain while most of the stand was removed. The site could then be burned during summer of the same year or the next year. The remaining Alaska yellow-cedars, which would probably have been killed by fire, could then be harvested during winter or spring following their seed release in fall. Seeds released from the dead trees may be viable and may establish seedlings in good numbers because of the reduced level of competing vegetation.

Regenerating Alaska yellow-cedar on poorly drained sites will present a challenge because nursery-grown seedlings will perish in the mucky soil. Selection of drier microsites by planters will improve seedling survival. Alaska yellow-cedar exists as asexually reproducing understory in many of these stands (6); perhaps it could be encouraged to grow into trees following some stand treatment, such as salvage and thinning. Some mortality of Alaska yellow-cedar trees that occur from planting or natural regeneration on sites that already exhibit decline should be expected. However, forest managers can plant Alaska yellow-cedar on productive sites without fear of decline spreading to the plantation. Since its onset more than 100 years ago, decline of Alaska yellow-cedar has shown no ability to spread to new sites (3).

Private timber companies in British Columbia perceive a valuable future market in Alaska yellow-cedar as a specialty wood. Approximately 900,000 Alaska yellow-cedars are planted every year on productive sites in coastal British Columbia. "Stecklings," asexually reproduced rooted cuttings, account for most of the planting stock. In the last year, the Wrangell Ranger District of the Tongass National Forest has initiated efforts to plant nursery-grown seedlings of Alaska yellow-cedar on a commercial scale on productive harvested sites. Uncertainties still remain with techniques of managing stands of Alaska yellow-cedar once they have been established using natural regeneration or planting. Silvicultural information is needed in both British Columbia and Alaska on planting spacing, thinning, and pruning and their effects on wood quality and volume production.

Planting of Alaska yellow-cedar may be needed to attain adequate regeneration of this valuable tree species in southeast Alaska. This study provides preliminary information on planting requirements of Alaska yellow-cedar. Planting recommendations are listed below.

PLANTING RECOMMENDATIONS

Results from this study suggest that seedlings of Alaska yellow-cedar will have good survival and growth in southeast Alaska if the following practices are followed:

1. Plant in areas of *good light exposure*.

2. Plant on sites with *good moisture drainage*. Even on productive sites, use care in avoiding microsites with poor drainage. Certain vegetation, such as skunk cabbage, can indicate these wet microsites.

3. *Plant early* after harvesting to avoid unnecessary competition from hemlock and brushy vegetation.

4. Consider *burning* as site preparation. Burning increases seedling survival and growth.

5. Use *protection* from deer grazing (e.g., vexar) in areas of deer populations, particularly on burned sites.

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